Temperature and Heat

Temperature

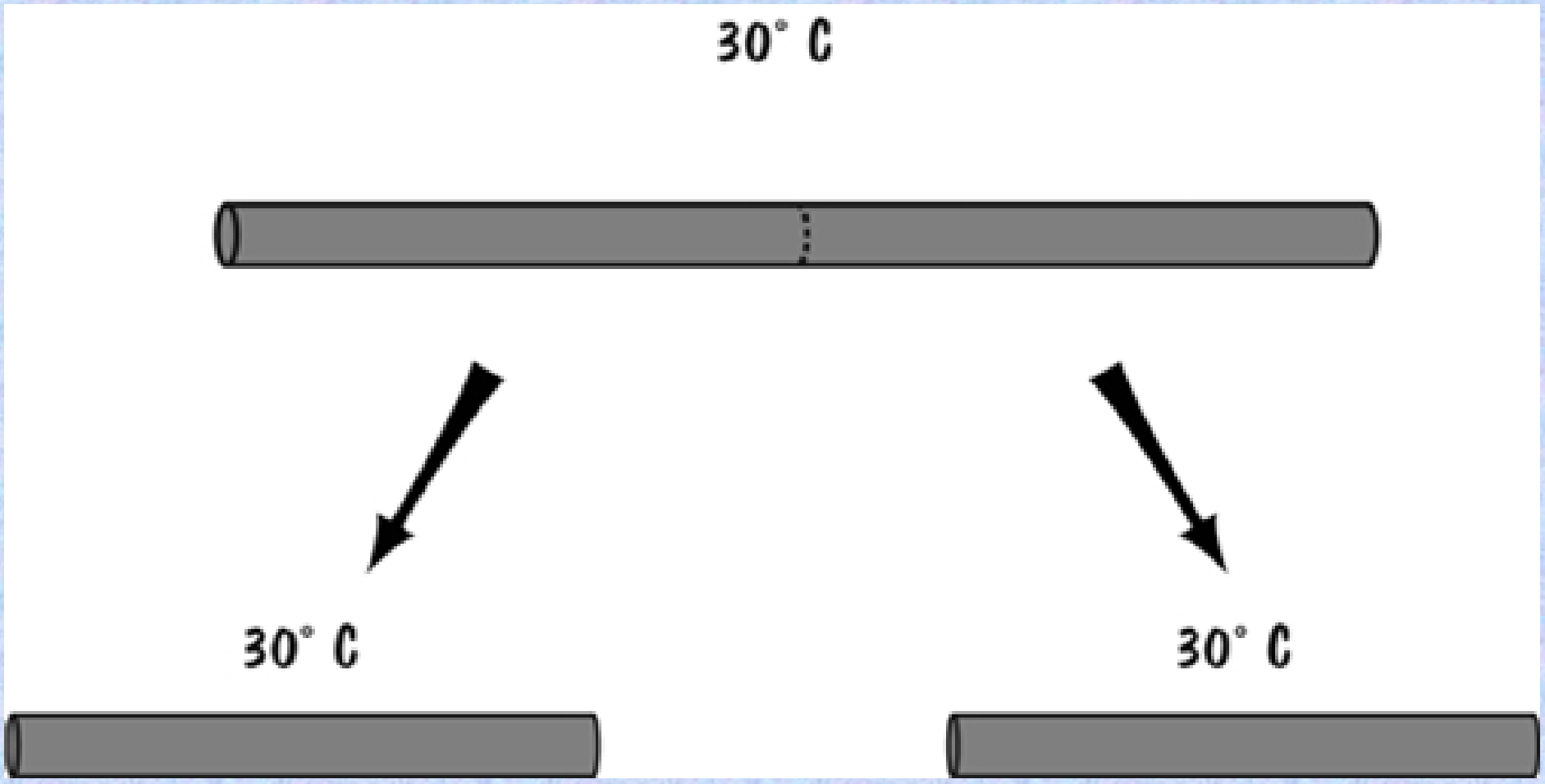
- We often associate the concept of temperature with how hot or cold an object feels when we touch it. Thus, our senses حواسنا provide us with a qualitative indication of temperature. However, our senses are unreliable and often mislead us.
- وكثيرا ما تخدعنا

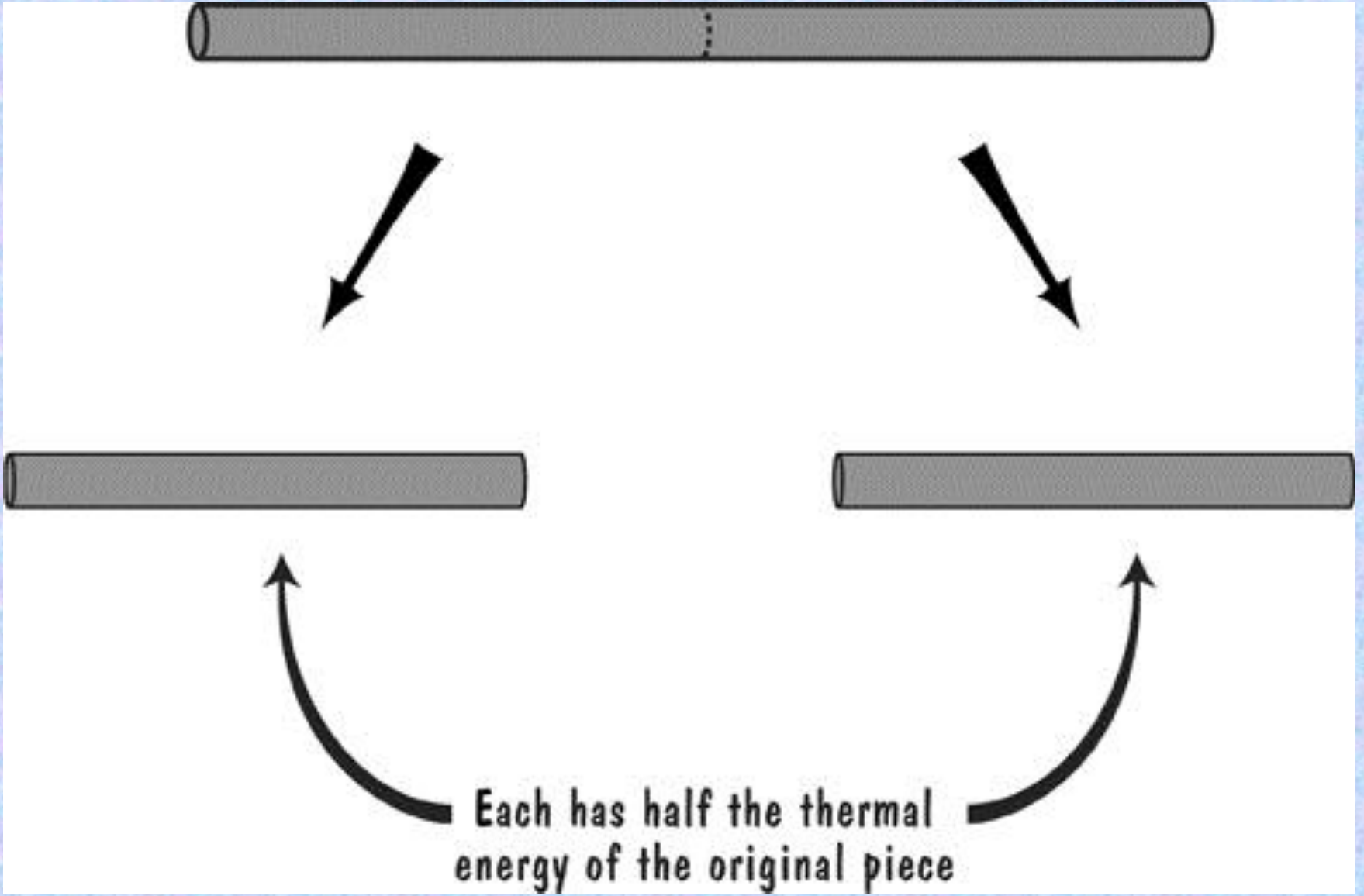
Temperature

- So, the temperature is defined as the average energy of the object's molecules. and
- It is used to specify how hot or cold an object feels.
- Temperature depends on the transnational molecular motion.

Temperature is a measure of…

- **The total amount of energy in an object**
- **How fast the molecules in an object are moving**


30° C
30° C
30° C


Each has half the thermal
energy of the original piece

Heat is…

- **It is The total amount of molecular energy of the object.**

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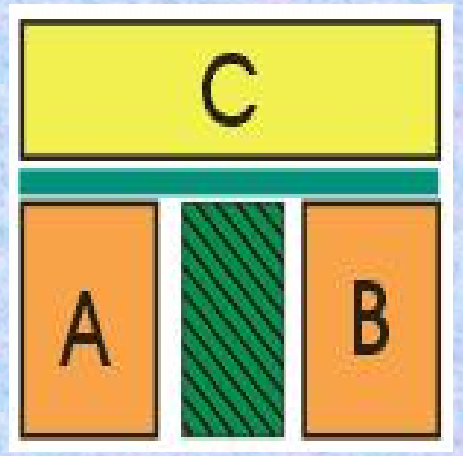
- **Heat is defined as the transfer of energy across the boundary of a system due to a temperature difference between the system and its surroundings.**
- **i.e.**
- **Transfer energy from one body to another due to the difference in temperature**

Thermal Equilibrium

❖ **Two systems are in thermal equilibrium if and only if they are at the same temperature.**

Zeroth Law of Thermodynamics

- **If objects A and B are separately in thermal equilibrium with a third object C, then, A and B are in thermal equilibrium with each other.**



➢**In General,**

➢If three or more systems are in thermal contact with each other and all in equilibrium together, then any two taken separately are in equilibrium with one another

Thermal Energy = internal energy

= a measure of the total kinetic and potential energy in an object

How do we measure temperature?

Think about using a thermometer

How does the thermometer know how hot the substance is?

Thermometer

- It is a device used to measure the temperature of objects.

A thermometer is an instrument that measures the temperature of a system in a quantitative way.

The easiest way to do this is to find a substance having a property that changes in a regular way with its temperature.

Physical properties used to measure temperature

Change In

- volume of a liquid
- length of solid
- volume of a gas at constant pressure
- pressure of a gas at constant volume
- electric resistance of a conductor
- color of a very hot body

SCALES OF TEMPERATURE

- It is necessary to have a fixed scale of temperature.
- The scale must be defined by two fixed reference points:

Lower fixed point: *this is the temperature of pure melting ice at a pressure of* 1 atm.

Upper fixed point: *this is the temperature of dry steam from water boiling at a pressure of* 1 atm.

***The temperature scales are*:**

Celsius, Fahrenheit, and Kelvin.

***Fundamental interval*: is the difference between the two fixed points, and divided into a number of equal divisions, each division representing one degree.**

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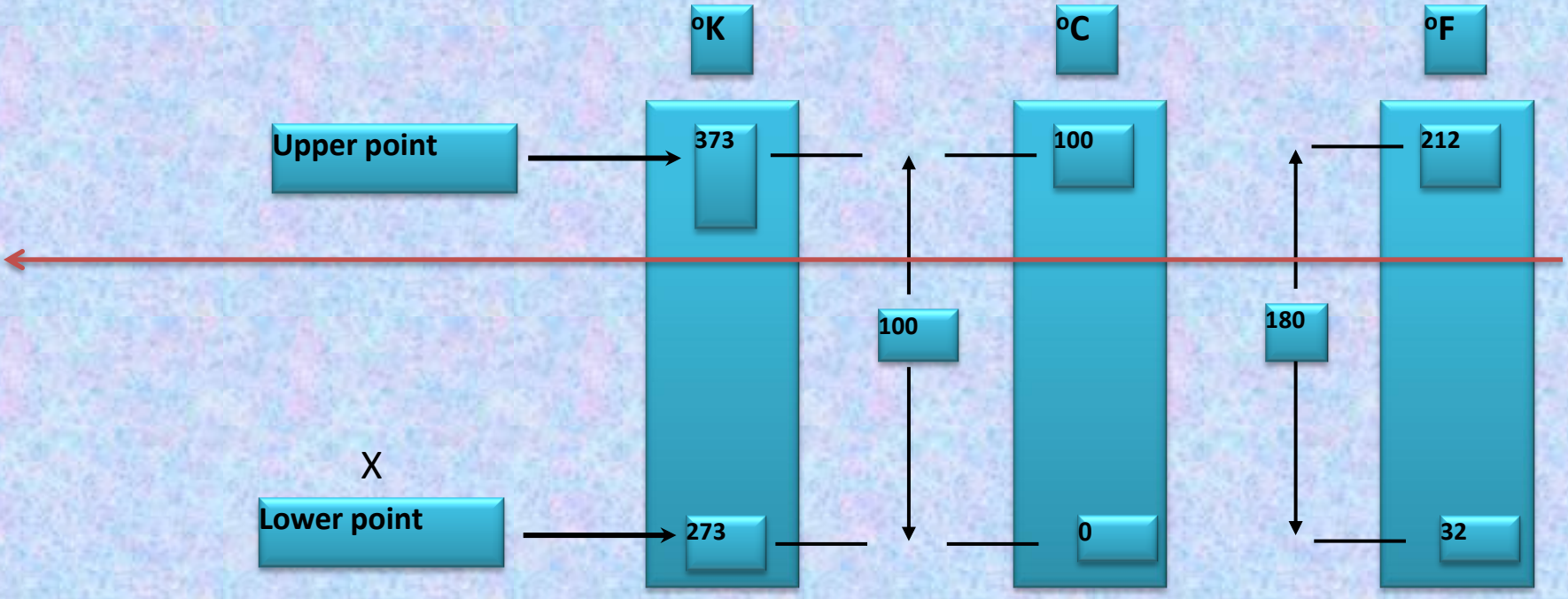

$$\frac{T_k - 273}{373 - 273} = \frac{T_c - 0}{100 - 0} = \frac{T_F - 32}{212 - 32}$$

$$\frac{T_k - 273}{100} = \frac{T_c - 0}{100} = \frac{T_F - 32}{180}$$

$$T_K = T_C + 273 \qquad T_F = \frac{9}{5}T_c + 32 \qquad T_c = \frac{5}{9}(T_F - 32) \qquad T_K = \frac{5}{9}(T_F - 32) + 273$$

Common Temperature Readings

Temparature	Celsius C	Fahrenheit F	Kelvin K
Boiling point (water)	100	212	373
Freezing point (water)	0	32	273
Absolute zero	-273	-459	0
Body Temperature	37	98.6	310

Examples

- **You place a small piece of melting ice in your mouth. Eventually, the water all converts from ice at $T_1 = 32\ ^oF$ to body temperature, $T_2 = 98.6\ ^oF$. Express these temperatures as ^oC and K, and find $\Delta T = T_2 - T_1$, in both cases?**

- **Answer**

$$T_1 = 32^\circ F \quad \text{and} \quad T_2 = 98.6^\circ F$$

$$T_C = \frac{5}{9}(T_F - 32)$$

$$T_1 = \frac{5}{9}(32 - 32) = 0^\circ C$$

$$T_2 = \frac{5}{9}(98.6 - 32) = 37^\circ C$$

$$\Delta T_F = (98.6 - 32) = 67.6^\circ F$$

$$\Delta T_C = (37 - 0) = 37^\circ C$$

Example (2)

The extremes of temperature in the bottom of the earth, over a period of 50 years, differ by 116 ^{o}F.

Express this range in Celsius degree?

Answer

$$\Delta T_F = 116^{o}\ K$$

$$T_C = \frac{5}{9}(T_F - 32) \Rightarrow \Delta T_C = \frac{5}{9}\Delta T_F$$

$$\Delta T_C = \frac{5}{9}\Delta T_F = \frac{5}{9} * 116 = 64.44^{o}\ C$$

Example (3) : ***Conversions between temperature scales***

What is 0°K on;

(a) the Celsius scale,

(b) the Fahrenheit scale,

(c) What is a room temperature of 72°F on the Celsius scale?

$$T_K = 0^o K$$

(a)

$$\because \quad T_K = T_C + 273 \quad \Rightarrow \quad T_C = T_K - 273 = 0 - 273 = -273^o C$$

(b)

$$\because \quad T_F = \frac{9}{5} T_C + 32 \quad \Rightarrow \quad T_F = \frac{9}{5}(-273) + 32 = -459.4^o F$$

(c)

$$\because \quad T_F = \frac{9}{5} T_C + 32 \quad \Rightarrow \quad T_c = \frac{5}{9}(T_F - 32) = \frac{5}{9}(72 - 32) = 22^o C$$

• SUMMARY

- Two objects are in thermal equilibrium with each other if they do not exchange energy when in thermal contact.
- **The zeroth law of thermodynamics states** that if objects A and B are separately in thermal equilibrium with a third object C, then objects A and B are in thermal equilibrium with each other.
- **Temperature** is the property that determines whether an object is in thermal equilibrium with other objects.

$$\Delta T_C = (5/9)\ \Delta T_F$$

$$\Delta T_C = \Delta T_K$$

$$\Delta T_F = (9/5)\ \Delta T_C$$

$$\Delta T_K = \Delta T_C$$

- Quick Quiz Two objects, with different sizes, masses, and temperatures, are placed in thermal contact. Energy travels
- (a) from the larger object to the smaller object.
- (b) from the object with more mass to the one with less.
- (c) from the object at higher temperature to the object at lower temperature.